ANALYSIS AND APLICATION OF DUAL-POL SAR IMAGERY

T.L. Ainsworth[1] and J.-S. Lee[1,2]

[1]Remote Sensing Division, Naval Research Laboratory, Washington, DC 20375, USA
[2]Center for Space and Remote Sensing Research, National Central University, Chung-Li, Taiwan

1. INTRODUCTION

Analysis of dual polarimetric SAR imagery has taken on new importance with the launches of the ALOS PALSAR, TERRASAR-X and RADARSAT-2 polarimetric SAR systems. While these space borne, polarimetric SARs can provide full polarimetric imagery, the majority of the collected imagery will be restricted to dual polarimetric imaging modes. We review polarimetric analysis methods specific to the dual-pol imaging modes typically available from these space borne SAR systems, i.e. (HH, VH), (VV, HV) and (VV, HH). However, two important questions remain: How best to analyze the dual polarimetric imagery collected by these space borne polarimetric SAR systems? And, which applications allow effective use of dual-pol, rather than full quad-pol, SAR imagery?

The two polarimetric analysis techniques that we review and assess are the eigenvector / eigenvalue decomposition of the dual-pol covariance matrices, and the dual-pol signature plots. Eigenvector / eigenvalue analysis is a well known technique borrowed from full quad-pol SAR imagery analysis. Applied to quad-pol imagery the Cloude-Pottier polarimetric decomposition has proved very useful. However, when applied to dual-pol imaging modes the meaning and interpretation of the eigenvectors characterizing dual-pol scattering mechanisms differs from the quad-pol case. Since the polarimetric information retrieved from an (HH, VH) dual-pol image is not the same as information from a (VV, HV) image pair, the interpretation of dual-pol scattering mechanisms depends upon the imaging mode. The familiar quad-pol alpha-entropy plot separates different scattering mechanisms by the average alpha angle, and polarimetric randomness by the entropy. While for the dual-pol version of this plot the entropy still shows polarimetric randomness, the meaning of the second variable, the "dual-pol alpha angle", depends upon the dual-pol imaging mode, e.g. (HH, VH) or (VV, HV).

The so-called dual polarization signature plots provide a convenient, graphical means to display dual-pol scattering information. Whenever a single polarization is transmitted and orthogonal polarizations are coherently received, the ellipticity and orientation angles completely characterize the received polarization. For a given scatterer and transmitted polarization, the dual polarization signature displays the strength of the backscattered return as a function of the orientation and ellipticity angles. The dual-pol signature plot displays the complete polarimetric information available for any dual-pol imaging mode. These dual-pol signature plots provide a quick and accurate assessment of dual-pol scattering properties.

We apply these two complementary dual-pol analysis techniques to a variety of scattering scenarios and applications, e.g. agricultural plots, forestry, urban areas. We employ both dual-pol and quad-pol imagery as the basis of all comparisons both amongst the various dual-pol imaging modes and with the full quad-pol data. The primary results of this work are the assessments of the applicability of individual dual-pol imaging modes to the different scattering scenarios.

2. SUMMARY

We review the dual-pol analysis techniques that, by design, fully exploit the complete polarimetric information available from dual-pol imaging modes. We utilize both dual-pol and quad-pol imagery as a basis for assessing the applicability of dual-pol SAR imagery for different scattering mechanisms and imaging scenarios. This assessment will suggest the best uses of dual-pol imaging modes for polarimetric SAR applications. So, while full quad-pol data provides complete polarimetric scattering information this work will indicate possible applications for which dual-pol imaging modes are sufficient.